

Yoga for Pain: A Research Review

Tiffany Field*

Touch Research Institute, Miller School of Medicine, University of Miami, USA and Fielding Graduate University, USA

***Corresponding author:** Tiffany Field, Touch Research Institute, Miller School of Medicine, University of Miami, USA and Fielding Graduate University, USA. Tel: +13052436781; Fax: +13052436488; Email: tfield@med.miami.edu

Citation: Field T (2018) Yoga for Pain: A Research Review. Yoga Phys Ther Rehabil: YPTR-151. DOI: 10.29011/YPTR-151.000051

Received Date: 28 December, 2017; **Accepted Date:** 22 January, 2018; **Published Date:** 30 January, 2018

Abstract

Yoga is frequently used for pain syndromes. For this narrative research review, PubMed and PsycINFO were searched for the terms chronic pain and yoga to identify publications from the last ten years. Inclusion criteria were randomized controlled trials, systematic reviews and meta-analyses that were peer-reviewed and published in English. The pain conditions include low back pain (the most frequently studied condition), headaches, neck pain, osteoarthritis, rheumatoid arthritis, irritable bowel syndrome, premenstrual syndrome and labor pain. These studies showed significant effects of yoga on pain especially when compared to standard treatment. In contrast, when yoga was compared to exercise, the data have been less conclusive. Potential underlying mechanisms that have been explored for the yoga-pain reduction relationship include an increase in vagal activity. Limitations of this literature include a limited number of randomized controlled trials and the frequent absence of a suitable comparison group.

Yoga for Pain: A Research Review

This paper is a narrative review of empirical studies, reviews and meta-analyses on yoga effects on pain conditions. The terms yoga and pain were entered into PubMed and PsycINFO to identify publications from the last ten years. Inclusion criteria were randomized controlled trials, systematic reviews and meta-analyses that were peer-reviewed and published in English. Exclusion criteria included case studies, small sample pilot studies and studies that were not assessor-blinded. The studies reflect the last decade literature on yoga effects on pain including low back pain, headaches, neck pain, knee osteoarthritis, rheumatoid arthritis, premenstrual syndrome, prenatal and labor pain, cystic fibrosis, multiple sclerosis and irritable bowel syndrome. These and underlying mechanism studies are critically reviewed and suggestions are given for future research

Many forms of yoga were practiced in these studies including Hatha yoga which is considered the most relaxing form, Ashtanga as a series of poses referred to as power yoga, Anasara as characterized by its free-flowing movements called Vinyasa and Iyengar featuring a longer holding of poses. Because most yoga classes involve poses and breathing exercises as well as meditation, it is difficult to assess their separate effects. Although there is limited research on potential underlying mechanisms for yoga effects, the effects may be similar to those of massage therapy in-

asmuch as yoga is a kind of self-massage including the rubbing of limbs against each other and against the floor. Both massage and yoga stimulate pressure receptors under the skin which, in turn, would lead to enhanced vagal activity and reduced cortisol [1]. These physiological and biochemical changes would be accompanied by reduced pain.

Chronic Pain Syndromes

Low Back Pain

A preponderance of yoga studies has focused on low back pain which has typically decreased following yoga. In one study, for example, adults with chronic low back pain were randomly assigned to a yoga group (12 weekly sessions of yoga), a therapeutic exercise group or a self-care group (assigned to read and practice exercises in a book). At the end of the study the yoga participants reported less analgesic and opiate use than the other two groups [2].

In another study on back pain, women were randomly assigned to yoga and control groups [3] The yoga program included physical poses, breathing and meditation. The control group practiced physical exercises and was given didactic sessions on lifestyle change. The yoga group had decreased disability scores and showed greater increases in spinal flexion, right lateral flexion and left lateral flexion. The reduction in sleep disturbances in that

group may explain the reduction in pain given that less substance P (causing pain) is emitted when sleep is less disturbed [4].

Similar effects were noted in a comparison between Iyengar yoga and a waitlist control group [5]. The yoga group at the end of the 6-month intervention period (90-minute classes twice per week) showed less functional disability and reported less pain. In another randomized controlled study on chronic low back pain, an Iyengar yoga group was compared to a conventional exercise group [6]. The yoga group was trained in 29 different Iyengar yoga poses which by virtue of being held longer makes Iyengar a more strenuous form of yoga and likely equivalent to exercise in its intensity. Both groups showed significant reductions in pain, although the yoga group showed almost twice the reduction in pain as compared to the exercise group.

A shorter, one-week intensive yoga program has also been effective [7]. This program included poses, breathing exercises, meditation, and didactic interactive sessions on the philosophy of yoga. The control group practiced physical exercises with a trained physiatrist and had didactic interactive sessions on lifestyle change. The yoga group showed greater improvement as compared to the control group on spinal flexion, spinal extension, right lateral flexion and left lateral flexion. Once again, however, the yoga sessions were multifaceted including poses, breathing exercises and meditation, suggesting that these different exercise effects were confounded.

Yoga has become an increasingly popular therapy for veterans, although the literature on those programs is limited. A recent review of that research suggested that only six studies could be found [8]. In addition, four of these studies used a pre-post design. Other methodological problems were the small sample sizes and the lack of studies with active duty military. In a randomized controlled group on active military, pain was reduced by a program involving 9-12 individual yoga sessions as compared to a standard treatment group for 8 weeks. Secondary variables did not change. Finding pain reduction has been typical of most yoga studies while secondary measures have frequently not changed. Another example of secondary variables not changing is a yoga study for individuals with MRI-based degenerative spinal changes along with low back pain [9]. The yoga group was taught postures, breathing and relaxation techniques one hour daily for three months. As compared to a standard treatment group, the yoga group experienced reduced pain but no improvement in MRI-based degenerative discs.

When yoga has been compared to active versus inactive control groups, the yoga effects on pain are less conclusive. For example, yoga has been compared with physical therapy and education classes [10]. After 12 weeks, the yoga and physical therapy participants were 22% less likely than the education group to use pain medication. This advantage was maintained across one year, although the physical therapy group had a greater loss to follow-up.

Yoga has also been compared to qigong for low back pain [11]. In this study, 176 older adults with low back pain were randomly assigned to a yoga, a qigong or control group. There were no group differences on pain reduction. Although the authors suggested that possible explanations for the lack of pain relief were ineffectiveness of the interventions, they did not address the attrition issue. The treatment parameters also differed between groups, i.e. 24 classes of 45 minutes for yoga and 12 classes of 90 minutes for qigong). A compliance problem could also explain the null findings.

Despite this null finding, at least three systematic reviews and a review of reviews have documented pain reduction for low back pain following yoga. One of these documented a reduction in pain across yoga studies in general for chronic low back pain [12]. In another review, six studies were identified that included 570 patients who were given Iyengar yoga for both back and neck pain [13]. These authors found strong evidence for short-term pain reduction but limited evidence for long-term effectiveness of yoga. In a third review including searches of eight databases, 12 trials on 1080 participants from three different countries were identified [14]. Most of the trials featured Iyengar yoga and compared yoga to non-intervention, non-exercise intervention and exercise intervention groups. The authors suggested that all trials were at risk for performance and detection bias because both the providers and the participants were not blind to the treatment assignment, and the outcomes were based on self-reports. Although they concluded that there was low to moderate evidence that yoga as compared to non-exercise controls resulted in small to moderate decreases in pain at three and six months, there was uncertainty about yoga being more effective than exercise for back-related function or pain. Contrary to those conclusions, another systematic review of three systematic reviews suggested significant pain reduction following yoga for both the short and the long term [15]. However, no studies could be found on the prevention or treatment of acute low back pain.

A couple studies have addressed preferences and attitudes regarding yoga. In one study preference for more frequent yoga classes was expressed by participants with greater back pain [16]. Those individuals who preferred more yoga classes had higher expectations for the classes. However, the preferences and expectations were not related to the change in back pain intensity after three months of yoga. In another study, participants completed questionnaires that assessed attitudes about yoga, fear of movement and pain catastrophizing [17]. Individuals with higher levels of fear of movement and catastrophizing were less likely to consider yoga for their pain treatment.

Headaches

In one study, individuals with migraine headaches were randomly assigned to a yoga or a self-care (stress-reducing) group [18]. After 3 months of weekly sessions, the intensity and frequency of headache pain decreased and medication use was lower

in the yoga group. In a randomized controlled study on migraine headaches, a medication group was compared to a medication plus yoga group who had 3 months of yoga training [19]. The yoga group experienced reduced headache frequency and severity. In another randomized controlled trial, a routine care group was compared to a routine care plus yoga group that attended sessions five days a week for six weeks [20]. The yoga group showed a greater reduction in headache frequency and intensity, and they also had increased vagal activity. This finding suggests that yoga increases vagal activity, and it may be the mediating variable for many of the therapeutic effects of yoga [21].

Neck Pain

In a chronic neck pain study, a yoga group was compared to a Pilates group [22]. Following ten sessions, pain and disability decreased in both groups, although, surprisingly, no changes were noted on the more objective range of motion and posture measures.

In a systematic review of five electronic databases between the years 1956 and 2015, only three randomized controlled trials were found on yoga effects on chronic neck pain [23]. The author's conclusion was that neck pain intensity and functional disability were reduced more significantly in the yoga versus control groups. Unfortunately, the control groups were again non-exercise groups. In a systematic review and meta-analysis, three studies on 188 patients compared yoga with usual care [24]. The authors reported short-term effects for neck pain intensity, for neck pain-related disability as well as for quality of life and mood. Again, the non-exercise and standard treatment control groups are not appropriate comparison groups for yoga effects.

Knee Osteoarthritis

In a randomized controlled study on knee osteoarthritis that focused on specific physical measures, the participants were randomly assigned to Hatha yoga or therapeutic exercises after having transcutaneous electrical stimulation and ultrasound treatment [25]. The intervention groups met for 40 minutes per day for three months. Although there were no significant differences between the yoga and exercise groups, the yoga group improved more than the control group on walking pain, knee disability, range of knee flexion, joint tenderness, swelling, and walking time.

In a study on older adults, Hatha yoga and aerobic/strengthening exercises were compared [26]. In this randomized controlled study, both groups attended eight weekly 45-minute group classes and had home practice sessions two-four days per week. The control group received osteoarthritis education brochures. At the end of the study, although both intervention groups showed improvement, the participants in the Hatha yoga group had significantly fewer arthritis symptoms as well as less anxiety and less fear of falling. Chair yoga has also been tried with older adults who had knee osteoarthritis but could not participate in standing exercises

[27,28]. In these randomized controlled trials, chair yoga was compared to a health education program. Participants engaged in twice weekly 45-minute chair yoga or health education sessions. The chair yoga group showed a significant decrease in pain interference [27]. This effect was sustained through three months [28]. However, although improvements were noted for the yoga group in gait speed and fatigue, those effects were not sustained. In addition, not surprisingly, chair yoga had no effect on balance.

In a randomized controlled study on knee osteoarthritis in older women, the participants were randomly assigned to an eight-week yoga program involving group and home sessions or to a waitlist control group [29]. The yoga group outperformed the waitlist control group on reduction in pain, stiffness, and sleep disturbances by the end of the treatment period. In a survey on older women who were six months post-osteoarthritis yoga, the majority of the women reported that they were still practicing yoga 21 to 30 minutes per day 3 to 4 days per week and having less pain [30]. Feeling better after yoga practice was the most common motivating factor for continuing yoga, and dealing with health problems, having pain and being too busy were the major deterrents to continuing yoga.

Several reviews have been published on yoga for knee osteoarthritis pain. In one of these reviews, most of the studies had measured pain by a scale called the WOMAC [31,32]. And, in most of the studies reviewed, pain was significantly reduced especially following Iyengar classes focused on poses as opposed to classes that had integrated protocols (poses, breathing and meditation exercises). In a focused review, 12 studies including 589 participants met inclusion [33]. Hatha and Iyengar were the most popular yoga forms, and the frequency of classes ranged from once a week to six days a week and the duration of classes ranged from 6 to 12 weeks. The results included reduced pain, stiffness and swelling. Physical function and well-being data were inconclusive because of the variety of measures used. In a systematic review, six studies that met criteria involved 372 patients with knee osteoarthritis [34]. In this review, the most frequent yoga protocol was 45 to 90 minutes per session lasting for at least eight weeks. However, pain reduction and improvement in function was seen as early as two weeks after the first class.

In a review of the literature on knee osteoarthritis symptoms, 12 studies met inclusion criteria involving 589 participants [33]. Iyengar and Hatha were the most frequently used types, and the frequency ranged from once a week to every day and for 45 to 90 minutes per session for 6 to 12 weeks. In these studies, yoga resulted in decreased pain, swelling and stiffness. Methodological problems across these randomized controlled trials included several studies having small sample sizes as well as different yoga routines that varied in length. For these reasons and because of the variety of outcome measures, these results are inconclusive.

Rheumatoid Arthritis

In a randomized controlled trial on the feasibility of yoga for rheumatoid arthritis, retention rates were 100 percent for yoga participants who attended a median of seven classes [35]. In addition, 54% of the yoga participants reported doing yoga at home during the follow-up. No serious adverse events were reported.

In another study, 75 adults with rheumatoid arthritis were randomly assigned to a yoga or waitlist control group [36]. The yoga group had two one-hour classes and one home practice session per week. Of the rheumatoid arthritis sample, 96% were female, 55% were white and 51% were college educated. Following two months, the yoga group had less pain, greater walking capacity, more positive affect and lower depression scores. Physical variables like balance, grip strength and flexibility were similar in the two groups. In another study, adults with rheumatoid arthritis attended bi-weekly Iyengar yoga classes for 6 weeks [37]. Pain and pain disability were reduced by the end of the treatment period.

Long-term effects of yoga have been noted in at least one randomized controlled study on rheumatoid arthritis. In that study, a yoga group attended 60-minute classes twice per week for two months and was compared to a waitlist control group [36]. The yoga group showed significantly better performance on the six-minute walk test, on flexibility and on quality of life variables at two months and as long as nine months later. However, rheumatoid arthritis patients were grouped with knee osteoarthritis patients in this study. And Hatha yoga poses were combined with breathing exercises and meditation, thus confounding the treatment effect. In addition, the poses were modified for the participants' individual needs which introduced further treatment variability.

Irritable Bowel Syndrome

Irritable bowel syndrome is the most common gastrointestinal disorder [38]. In this twice per week six-week Iyengar yoga study, individuals with irritable bowel syndrome were compared with a waitlist control group. The yoga group experienced a reduction in bowel syndrome symptoms including pain, constipation and nausea, and the symptom reduction was maintained at the two months follow-up assessment.

In another irritable bowel syndrome study, the group who received yoga for 8 weeks for one hour/day reported intestinal colic pain [39]. This intensive yoga program was comprised of poses, breathing and meditation exercises, once again confounding the question of which aspect of yoga was effective.

In a comparison between Iyengar yoga and walking, positive effects were noted for both groups following 16 bi-weekly sessions [40]. Irritable bowel syndrome symptoms decreased for the yoga group, and overall gastro-intestinal symptoms decreased for the walking group. The walking group continued to benefit at a six-month follow-up, but the yoga group showed no sustained im-

provement, probably because the walking group reported walking more often than the yoga group practiced yoga.

In a randomized controlled trial on pediatric abdominal pain, 69 children were randomly assigned to a yoga or to a standard medical care group [41]. The yoga group met once a week for 10 weeks. At a one-year follow-up, the yoga group had a significant reduction in both pain intensity and pain frequency scores as well as less school absenteeism. The sustained effects may have resulted from continuing yoga practice by the yoga group, although that was not measured.

In a systematic review of the literature on several databases including PubMed and the Cochrane Library, six randomized, controlled trials met criteria with a total of 273 patients with irritable bowel syndrome [42]. As compared to standard treatment, non-pharmacologic and pharmacologic treatments, the yoga group had a greater decrease in bowel symptoms and in the severity of irritable bowel syndrome as well as anxiety.

Premenstrual Syndrome

A few studies were found in the literature on yoga for premenstrual syndrome. In one study, 64 women with premenstrual syndrome were given a 12-week yoga exercise program [43]. At the end of the three-month period, the women reported less body pain, abdominal swelling, abdominal cramps and breast tenderness and decreased use of analgesics during menstruation. In another study on primary dysmenorrhea, 34 young women were randomly assigned to yoga and standard treatment groups [44]. The yoga group participants were asked to practice yoga at home for 30 minutes a day, two times a week for three months. The yoga group had a significant decrease in menstrual pain. Increased physical fitness in the yoga group suggests that they had adhered to their yoga practice at home. In another randomized controlled trial, 40 undergraduate nursing students with primary dysmenorrhea were assigned to a yoga or control group [45]. The yoga group practiced for 60 minutes once a week for three months including physical exercise combined with relaxation and meditation. Based on a visual analogue scale for pain and the Menstrual Distress Questionnaire, menstrual pain intensity and menstrual distress scores decreased significantly by the end of the three-month period.

Other Gynecologic Pain Problems

Yoga research has also been conducted with women who had endometriosis, pelvic pain and gynecologic surgery. In a randomized controlled trial, 40 women with endometriosis were randomly assigned to a yoga or a control group [46]. The yoga participants attended 90-minute yoga sessions twice per week for two months. Pain intensity as well as pain scores on the Endometriosis Health Profile Questionnaire significantly decreased for the yoga group.

At least three studies on yoga for pelvic pain have appeared in the literature. In a single arm trial, yoga participants attended

twice weekly Iyengar sessions and were asked to practice at home one hour per week for six weeks [47]. The participants completed the Impact of Pelvic Pain Questionnaire and the Sexual Health Outcomes in Women Questionnaire and they were asked to keep daily logs on the severity of their pelvic pain. By the end of the six-week period, pain intensity had decreased as well as pelvic pain interference. In a randomized controlled study, one group received anti-inflammatory medications and the other group received yoga therapy including poses, breathing exercises and relaxation along with anti-inflammatory medications for two months [48]. At the end of the treatment period, the yoga group patients had a significant decrease in pain intensity as reported on a visual analogue scale. In a systematic review based on literature from the PubMed and Cochrane databases, only 15 of 1435 studies met criteria [49]. These suggested that women's pregnancy-related pelvic pain was reduced following yoga.

Labor Pain

In a labor pain study, yoga was practiced for six, one-hour sessions [50]. The yoga group experienced less labor pain than the control group and had a shorter first stage labor as well as a shorter total time in labor. In a randomized controlled study, 60 women were randomly assigned to a yoga or control group [51]. The prenatal yoga involved one-hour classes three times a week starting at 20 weeks gestational age. During labor, the yoga group had lower pain intensity at three–four centimeters dilatation and at two hours after that measurement. Those who completed the yoga class had shorter second and third stages of labor, reduced frequency of labor induction and a lower percentage of Caesarean section.

Autoimmune Conditions

Two autoimmune conditions that have been positively impacted by yoga include cystic fibrosis in children and multiple sclerosis in adults. In the cystic fibrosis study, 20 children were given six one-on-one sessions over ten weeks [52]. The sessions were comprised of yoga poses. The children experienced a reduction in joint pain as well as improved respiration. Unfortunately, this was a pre-post trial (single arm study) as opposed to a randomized controlled trial. In a randomized clinical trial, 90 multiple sclerosis patients were randomly assigned to a yoga, a walking or a control group [53]. The 40-minute sessions were held three times per week for three months. The yoga and the walking groups experienced reduced pain and fatigue.

Potential Underlying Mechanisms for Yoga Reducing Pain

Several different mechanisms have been explored for the pain reduction effects of yoga. Some have suggested that expectations about yoga reducing pain can influence pain perception. In a single session yoga study, 90 participants were assessed for their pain perception before and after a 60-minute session. Pain

perception was assessed by a calibrated peg that was applied for ten seconds to the middle finger, earlobe and second toe before and after the yoga session. Neither the expectations nor the previous yoga experience significantly influenced the participants' pain perception.

The Gate theory is the mechanism that has frequently been used to explain the pain reduction effects of massage therapy [54]. This might also be relevant for yoga given that yoga is a form of self-massage, as in limbs rubbing against limbs and against the floor and stimulating pressure receptors. According to the gate theory, pain receptors are shorter and less myelinated (less insulated) so the pain signal takes longer to reach the brain than the pressure signal which is carried by nerve fibers that are more insulated and longer and therefore able to transmit the stimulus faster. The pressure stimulus reaches the brain before the pain message and "Closes the gate" to the pain stimulus. This metaphor for the electrical and biochemical changes has been frequently used to explain the crazy bone effect of grabbing your elbow when it has been bumped.

The deep sleep theory is also used to explain pain reduction by yoga. Pain has been associated with substance P which is emitted when there is insufficient deep sleep. Yoga enhances sleep which might be expected to lead to decreased substance P and pain, although those three variables have not been measured together in a yoga study. The "Enhanced deep sleep leading to less substance P" theory has been assessed in a massage study on fibromyalgia [4]. Following a period of massage therapy in this study, more time was spent in deep sleep, and lower levels of substance P were assayed in the saliva samples taken. Similar measures might provide more confirmatory data for the sleep-enhancing and pain-reducing effects of yoga. Sleep has been enhanced in several yoga studies. In one study, for example, pregnant women who began prenatal Hatha yoga during the second trimester had fewer awakenings, less awake time during the night and less perceived sleep disturbance [55], and sleep disturbances were reduced in a study on older adults [56].

Still another theory is that yoga increases serotonin levels, serotonin being the body's natural anti-pain neurotransmitter. Serotonin, in turn, decreases substance P as well as other pain-associated hormones. Future yoga studies might use multiple physiological and biochemical measures to enhance our knowledge of the underlying mechanisms for the pain-alleviating effects of yoga. Increased serotonin could derive from increased vagal activity which has been noted in many studies.

In a pre-post, single arm design study on yoga effects on vagal activity, yoga was practiced daily for one month under the direction of a yoga instructor [57]. At the end of the month, the Low-Frequency (LF) power spectrum was reduced as was the LF/High-Frequency (HF) ratio, suggesting greater vagal activity. Unfortunately, this was not only a non-controlled study, but the com-

bination of yoga poses, breathing exercises and meditation also confounded the results. In a randomized controlled trial, the yoga group versus the control group showed reduced work-related stress and a significant increase in heart rate variability (vagal activity) following a 12-week program [58]. In a five-month program (90 minutes per day 6 days per week) the yoga group versus a control group showed a significant increase in heart rate variability (vagal activity) and a reduction in the LF/HF ratio [59].

In another study, healthy yoga practitioners practiced a yoga program and were compared to a control group [60]. Heart rate was higher in the yoga compared to the control group. And, the increase in heart rate variability (vagal activity) was greater for the yoga than the control group. In still another heart rate variability (vagal activity) study, 62 patients with chronic low back pain were randomly assigned to a three-month yoga or a standard treatment group [61]. The yoga group showed a significant decrease in the LF power of heart rate variability and a significant increase in the HF power of heart rate variability, suggesting a shift in the autonomic balance toward vagal dominance.

In a review on yoga effects on heart rate variability, 59 studies were reviewed including 2358 participants [62]. Of these studies, 15 were randomized controlled trials with six meeting criteria. These studies suggested that heart rate variability increases during yoga practice and yoga practitioners have greater vagal tone at rest compared to non-yoga practitioners. The authors cautioned that these data are not conclusive inasmuch as most of the studies had insufficient details on the study design and statistical methods and that corresponding changes in respiration needed to be reported. Yoga has also been associated with reduced cortisol which could result from enhanced vagal activity. In one study, patients with skeletal muscle pain syndrome were randomly assigned to a yoga or a non-yoga control group [63]. Following a three-month program, the yoga group had significantly lower cortisol levels.

Still others have suggested that antioxidant activity may reduce or prevent pain. In a study measuring antioxidants, 20 patients with shoulder pain were randomly assigned to a Hatha yoga or a control group [64]. After 16 weeks of 50-minute sessions three times weekly, the Hatha Yoga group had greater antioxidant activity. While it is conceivable that all of these mechanisms underlie the pain reduction following yoga, they have not been measured in the same sample following the same yoga protocol. More studies of this kind need to be conducted to replicate these findings as well as to understand any interaction or mediation effects of these mechanisms on pain reduction following yoga.

Limitations of Studies and Future Directions

Several methodological problems relate to the research designs of these studies. First, the samples vary on their yoga experience, with some studies including beginners and others experienced yogis. The groups would need to be equivalent on self-selection

factors such as these given that experienced yogis would be in better condition at baseline and more motivated to practice between sessions. Secondly, many trials are pre-post studies, others are mixed design (experimental versus control or waitlist control), and still others feature controls that may be as active as yoga such as a walking group. Less active groups such as education groups have also been used as control groups. Comparisons between yoga and the less active groups have typically favored the yoga group, but when yoga is compared to a more active group such as an exercise group, the yoga group advantage often disappears.

The variability in assessment protocols has also been problematic for grouping the studies for systematic reviews and meta-analyses. Pain has been mostly self-reported, which is not thought to be as reliable as more objective measures. Physical and physiological measures are rarely used, e.g. blood pressure, cortisol, substance P and other pain hormones (relatively easy to be assayed from saliva samples). Another problem is that different types of yoga, e.g. Hatha, Ashtanga and Iyengar yoga, have been offered for different conditions. Iyengar yoga with its longer poses is thought to be more intense as is Ashtanga yoga for its continuous movements. The different yoga types need to be compared in future studies given that a specific type of yoga may be more beneficial for a specific condition. Yoga sessions are also highly variable including individual versus group practice sessions and the dosage varies including the length of classes (20-90 minutes), frequency of classes (daily, weekly) and duration of the yoga program (weeks, months).

The results of the yoga studies are frequently confounded since the yoga sessions are a combined practice of poses, breathing exercises and meditation. Although the poses predominate most yoga sessions, the effects of the poses, breathing and meditation have not been parsed. That could be a reason why yoga is often considered less intense than exercise as it is coupled with meditation, resulting in lesser effects than the exercise group effects.

Future research should use randomized controlled studies in which yoga is compared to active exercise groups. Having established the benefits of yoga makes it ethically questionable to assign participants to less active control groups. Shorter sessions should be investigated for cost-effectiveness and for daily practice. Multiple physical and physiological measures need to be added to the self-report research protocols and potential underlying mechanisms need to be further explored. In the interim, the studies reviewed here highlight the therapeutic effects of yoga.

References

1. Field T, Diego M (2008) Vagal activity, early growth and emotional development. *Inf Behav Dev* 31: 361-373.
2. Saper RB, Cherkin DC, Erro J, Miglioretti DL, Deyo RA (2009) Comparing yoga, exercise, and a self-care book for chronic low back pain: a randomized controlled trial. *Altern Ther Health Med* 15: 18-27.

3. Chattha, R, Nagarathna, R, Padmalatha, V, Nagendra H (2008) Effect of yoga on cognitive functions in climacteric syndrome: a randomized control study. *BJOG* 115: 991-1000.
4. Field T, Diego M, Cullen C, Hernandez-Reif M, Sunshine W, Douglas S (2002) Fibromyalgia pain and substance P decrease and sleep improves after massage therapy. *Journal of Clinical Rheumatology* 8: 72-76.
5. Williams K, Abildso C, Steinberg L, Doyle E, Spstein B, Smith D, et al. (2009) Evaluation of the effectiveness and efficacy of Iyengar yoga therapy on chronic low back pain. *Spine (Phila PA 1976)* 34: 2066-2076.
6. Nambi GS, Inbasekaran D, Khuman R, Devi S, Shanmuganath, et al. (2014) Changes in pain intensity and health related quality of life with Iyengar yoga in nonspecific chronic low back pain: a randomized controlled study. *Int J Yoga* 7: 48-53.
7. Tekur P, Singphow C, Nagendra HR, Raghuram N (2008) Effect of short-term intensive yoga program on pain, functional disability, and spinal flexibility in chronic low back pain: a randomized control study. *J Altern Complement Med* 14: 637-644.
8. Miller S, Gaylord S, Buben A, Brintz C, Rae Olmstead K, et al. (2017) Literature review of research on chronic pain and yoga in military populations. *Medicines (Basel)* 4: 1-13.
9. Telles S, Bhardwaj AK, Gupta RK, Sharma SK, Monro R, et al. (2016) A randomized controlled trial to assess pain and magnetic resonance imaging-based (MRI-Based) structural spine changes in low back pain patients after yoga practice. *Med Sci Monit* 22: 3228-3247.
10. Saper RB, Lemaster C, Delitto A, Sherman KJ, Herman PM, et al. (2017) Yoga, physical therapy, or education for chronic low back pain: A randomized noninferiority trial. *Ann Intern Med* 167: 85-94.
11. Teut M, Knilli J, Daus D, Roll S, Witt CM (2016) Qigong or yoga versus no intervention in older adults with chronic low back pain- a randomized controlled trial. *J Pain* 17: 796-805.
12. Chang DG, Holt JA, Sklar M, Groessl EJ (2016) Yoga as a treatment for chronic low back pain: A systematic review of the literature. *J Orthop Rheumatol* 3: 1-8.
13. Crow EM, Jeannot E, Trewheala A (2015) Effectiveness of Iyengar yoga in treating spinal (back and neck) pain: A systematic review. *Int J Yoga* 8: 3-14.
14. Wieland LS, Skoetz N, Pilkington K, Vempati R, D'Adamo CR, et al. (2017) Yoga treatment for chronic non-specific low back pain. *Cochrane Database Syst Rev* 1: CD10671.
15. Goode AP, Coeytaux RR, McDuffe J, Duan-Porter W, Sharma P, et al. (2016) An evidence maps of yoga for low back pain. *Complement Ther Med* 25: 170-177.
16. Tran HH, Weinberg J, Sherman KJ, Saper RB (2015) Preference and expectation for treatment assignment in a randomized controlled trial of once- vs twice-weekly yoga for chronic low back pain. *Glob Adv Health Med* 4: 34-39.
17. Combs MA, Thorn BE (2015) Yoga attitudes in chronic low back pain: Roles of catastrophizing and fear of movement. *Complement Ther Clin Pract* 21: 160-165.
18. John PJ, Sharma N, Sharma CM, Kancane A (2007) Effectiveness of yoga therapy in the treatment of migraine without aura: a randomized controlled trial. *Headache* 47: 654-661.
19. Boroujeni MZ, Marandi SM, Esfarjani F, Sattar M, Shaygannejadi V, et al. (2015) Yoga Intervention on blood NO in female migraineurs. *Adv Biomed Res* 4: 259.
20. Kisan R, Sujana M, Adoor M, Rao R, Nalini A, et al. (2014) Effect of yoga on migraine: a comprehensive study using clinical profile and cardiac autonomic functions. *Int J Yoga* 7: 126-132.
21. Field T (2011) Yoga clinical research. *Complement Ther Clin Pract* 17: 1-8.
22. Dunleavy K, Kava K, Goldberg A, Malek MH, Talley SA, et al. (2015) Comparative effectiveness of pilates and yoga group exercise interventions for chronic mechanical neck pain: quasi-randomized parallel controlled study. *Physiotherapy* 102: 236-242.
23. Kim SD (2016) Effects of yoga on chronic neck pain: a systematic review of randomized controlled trials. *J Phys Ther Sci* 28: 2171-2174.
24. Cramer H, Klose P, Brinkhaus B, Michalsen A, Dobos G (2017) Effects of yoga on chronic neck pain: a systematic review and meta-analysis. *Clin Rehabil* 31: 1457-1465.
25. Ebnexar J, Nagathna R, Yogitha B, Nagendra HR (2012) Effects of an integrated approach of hatha yoga therapy on functional disability, pain, and flexibility in osteoarthritis of the knee joint: a randomized controlled study. *J Altern Complement Med* 18: 463-472.
26. Cheung C, Wyman JF, Resnick B, Savik K (2017) Yoga for managing knee osteoarthritis in older women: a pilot randomized controlled trial. *BMC Complement Altern Med* 14: 160.
27. Park J, Newman D, McCaffrey R, Garrido JJ, Riccio ML, et al. (2016) The effect of chair yoga on biopsychosocial changes in English- and Spanish-speaking community-dwelling older adults with lower-extremity osteoarthritis. *J Gerontol Soc Work* 59: 604-626.
28. Park J, McCaffrey R, Newman D, Liehr P, Ouslander JG (2017) A pilot randomized controlled trial of the effects of chair yoga on pain and physical function among community-dwelling older adults with lower extremity osteoarthritis. *J Am Geriatr Soc* 65: 592-597.
29. Cheung C, Wyman JF, Bronas U, McCarthy T, Rudser K, et al. (2017) Managing knee osteoarthritis with yoga or aerobic/strengthening exercise programs in older adults: a pilot randomized controlled trial. *Rheumatol Int* 37: 389-398.
30. Cheung C, Justice C, Peden-McAlpine C (2015) Yoga adherence in older women six months post-osteoarthritis intervention. *Glob Adv Health Med* 4: 16-23.
31. Field T (2016) Knee osteoarthritis pain in the elderly can be reduced by massage therapy, yoga and Tai Chi: A review. *Complement Ther Clin Pract* 22: 87-92.
32. Field T (2016) Yoga research review. *Complement Ther Clin Pract* 24: 145-161.
33. Cheung C, Park J, Wyman JF (2016) Effects of yoga on symptoms, physical function, and psychosocial outcomes in adults with osteoarthritis: a focused review. *Am J Phys Med Rehabil* 95: 139-151.
34. Kan L, Zhang J, Yang Y, Wang P (2016) The effects of yoga on pain, mobility, and quality of life in patients with knee osteoarthritis: a systematic review. *Evid Based Complement Alternat Med*: 6016532.
35. Ward L, Stebbings S, Athens J, Cherkin D, Baxter DG (2017) Yoga for the management of pain and sleep in rheumatoid arthritis: a pilot randomized controlled trial. *Musculoskeletal Care*.

36. Moonaz SH, Bingham CO 3rd, Wissow L, Bartlett SJ (2015) Yoga in sedentary adults with arthritis: Effects of a randomized controlled pragmatic trial. *J Rheumatol* 42: 1194-1202.
37. Evans S, Moieni M, Taub R, Subramanian SK, Tsao TC, Steinleib B, et al. (2010) Lyengar yoga for young adults with rheumatoid arthritis: results from a mixed-methods pilot study. *J Pain Sympt Manage* 39: 904-913.
38. Evans S, Lung KC, Seidman LC, Sternlieb B, Zeltzer LK, et al. (2014) Lyengar yoga for adolescents and young adults with irritable bowel syndrome. *J Pediatr Gastroenterol Nutr* 59: 244-253.
39. Sharma P, Poojary G, Dwivedi SN, Deepak KK (2015) Effect of yoga-based intervention in patients with inflammatory bowel disease. *Int J Yoga Therap* 25: 101-112.
40. Shahabi L, Naliboff BD, Shapiro D (2016) Self-regulation evaluation of therapeutic yoga and walking for patients with irritable bowel syndrome: a pilot study. *Psychol Health Med* 21: 176-188.
41. Korterink JJ, Ockeloen LE, Hilbink M, Benninga MA, Deckers-Kocken JM (2016) Yoga therapy for abdominal pain-related functional gastrointestinal disorders in children: a randomized controlled trial. *J Pediatr Gastroenterol Nutr* 63: 481-487.
42. Schumann D, Anheyer D, Lauche R, Dobos G, Langhorst J, et al. (2016) Effect of yoga in the therapy of irritable bowel syndrome: a systematic review. *Clin Gastroenterol Hepatol* 14: 1720-1731.
43. Tsai SY (2016) Effect of yoga exercise on premenstrual symptoms among female employees in Taiwan. *Int J Environ Res Public Health* 13: E721.
44. Yonglithipagon P, Muansiangsai S, Wongkhumngern W, Donpunha W, Chanavirut R, et al. (2017) Effect of yoga on the menstrual pain, physical fitness, and quality of life of young women with primary dysmenorrhea. *J Bodyw Mov Ther* 21: 840-846.
45. Yang NY, Kim SD (2016) Effects of a yoga program on menstrual cramps and menstrual distress in undergraduate students with primary dysmenorrhea: A single-blind, randomized controlled trial. *J Altern Complement Med* 22: 732-738.
46. Goncalves AV, Barros NF, Bahamondes L (2017) The practice of Hatha yoga for the treatment of pain associated with endometriosis. *J Altern Complement Med* 23: 45-52.
47. Huang AJ, Rowen TS, Abercrombie P, Subak LL, Schembri M, et al. (2017) Development and feasibility of a group-based therapeutic yoga program for women with chronic pelvic pain. *Pain Med* 18: 1864-1872.
48. Saxena R, Gupta M, Shankar N, Jain S, Saxena A (2017) Effects of yogic intervention on pain scores and quality of life in females with chronic pelvic pain. *Int J Yoga* 10: 9-15.
49. Kinser PA, Pauli J, Jallo N, Shall M, Karst K, et al. (2017) Physical activity and yoga-based approaches for pregnancy-related low back and pelvic pain. *J Obstet Gynecol Neonatal Nurs* 46: 334-346.
50. Chuntharapat S, Petpichetchian W, Hatthakit U (2008) Yoga during pregnancy: Effects on maternal comfort, labor pains and birth outcomes. *Complementary Therapies in Clinical Practice* 14: 105-115.
51. Jahdi F, Sheikhan F, Haghani H, Sharifi B, Ghaseminejad A, et al. (2017) Yoga during pregnancy: The effects on labor and delivery outcomes (A randomized controlled trial). *Complement Ther Clin Pract* 27: 1-4.
52. McNamara C, Johnson M, Read L, Vander Velden H, Thygeson M, et al. (2016) Yoga therapy in children with cystic fibrosis decreases immediate anxiety and joint pain. *Evid Based Complement Alternat Med*: 9429504.
53. Hasanpour Dehkordi A (2016) Influence of yoga and aerobics exercise on fatigue, pain and psychosocial status in patients with multiple sclerosis: a randomized trial. *J Sports Med Phys Fitness* 56: 1417-1422.
54. Field T, Diego M, Hernandez-Reif M (2007) Massage therapy research. *Developmental Review* 27: 75-89.
55. Beddoe AE, Lee KA, Weiss SJ, Kennedy HP, Yang CP (2010) Effects of mindful yoga on sleep in pregnant women: a pilot study. *Biological Research for Nursing* 11: 363-370.
56. Chen KM, Chen MH, Lin MH, Fan JT, Lin HS, et al. (2010) Effects of yoga on sleep quality and depression in elders in assisted living facilities. *Journal of Nursing Research* 18: 53-61.
57. Vinay AV, Venkatesh D, Ambarish V (2016) Impact of short-term practice of yoga on heart rate variability. *Int J Yoga* 9: 62-66.
58. Lin SL, Huang CY, Shiu SP, Yeh SH (2015) Effects of yoga on stress, stress adaptation, and heart rate variability among mental health professionals-a randomized controlled trial. *Worldviews Evid Based Nurs* 12: 236-245.
59. Nagendra H, Kumar V, Mukherjee S (2015) Cognitive behavior evaluation based on physiological parameters among young healthy subjects with yoga as intervention. *Comput Math Methods Med*: 821061.
60. Khattab K, Khattab AA, Ortak J, Richardt G, Bonnemeier H (2007) Lyengar yoga increases cardiac parasympathetic nervous system modulation among healthy yoga practitioners. *Evidence-Based Complementary and Alternative Medicine* 4: 511-517.
61. Telles S, Sharma SK, Gupta RK, Bhardwaj AK, Balkrishna (2016) Heart rate variability in chronic low back pain patients randomized to yoga or standard care. *BMC Complement Altern Med* 16: 279.
62. Tyagi A, Cohen M (2016) Yoga and heart rate variability: A comprehensive review of the literature. *Int J Yoga* 9: 97-113.
63. Ha MS, Baek YH, Kim JW, Kim DY (2015) Effects of yoga exercise on maximum oxygen uptake, cortisol level, and creatine kinase myocardial band activity in female patients with skeletal muscle pain syndrome. *J Phys Ther Sci* 27: 1451-1453.
64. HA MS, Kim DY, Baek YH (2015) Effects of Hatha yoga exercise on plasma malondialdehyde concentration and superoxide dismutase activity in female patients with shoulder pain. *J Phys Ther Sci* 27: 2109-2112.